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THE ECOLOGY AND REGENERATION OF ASPEN IN RELATION TO MANAGEMENT

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TABLE OF CONTENTS

214 THE ECOLOGY AND REGENERATION OF ASPEN
IN RELATION TO MANAGEMENT

PURPOSE

This paper presents information currently available on aspen ecology and reproduction. It was prepared to provide background data which may be useful when determining management practices on rangelands being invaded by aspen; however, the information applies equally as well on other areas since it is primarily a literature review. Additional studies on the ecology, physiology, and diseases of aspen are needed to clarify the interactions of the many variables affecting aspen reproduction.

INTRODUCTION

Aspen is clonal in nature and reproduces mainly from root suckering. Viable seed is produced each year, but climatic conditions prevent establishment of seedlings, at least in the western United States. It is generally not considered a climax type of vegetation, being eventually replaced by conifer stands. However, many stands continue indefinitely reproducing by sprouts after cutting, fire, or death of the parent stand because of age or disease.

If timber is harvested, or if the parent stand is altered by disease, the degree of reproduction that will be obtained becomes of major importance. The percentage of suckers able to survive under various intensities of use by cattle, sheep, and game animals is also of major concern. These factors will be affected by the soil, climate, and vegetative conditions.

LITERATURE REVIEW

Clonal Variation

Extensive work has been done in the aspen type to determine the factors affecting site quality and its relation to management. An important factor in management involves the control or enhancement of vegetative reproduction following timber removal. The genetic variability encountered within aspen will have an influence on the amount of reproduction obtained. Baker (1921) was one of the first to recognize genetic differences between clones. In central Utah, he found it was not uncommon to see a distinct line through the aspen with trees having fully developed leaves on one clone and the buds were just beginning to flush in the adjacent clone (see figure 1). Differences in bark coloration were also apparent as the early leafing trees had yellowish bark in contrast to the white or greenish bark on later leafing trees.

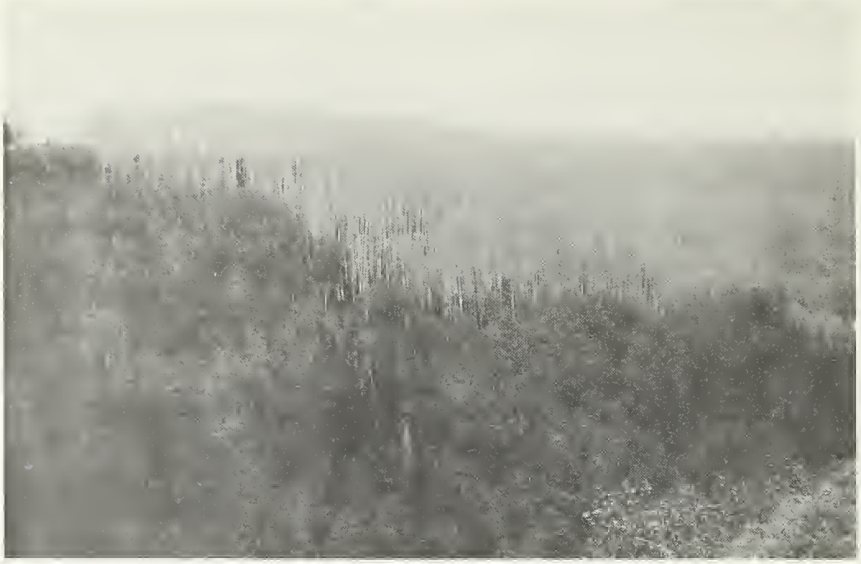

FIGURE 1

In addition to differences in date of leafing and bark coloration, other obvious clonal differences include growth form, shape and size of leaves, variation in fall coloration, and date of leaf fall (see figure 2). Sex is another variable, but is not as obvious. Aspen is dioecious with natural populations generally having many more staminate than pistillate trees.

FIGURE 2

Differences in root carbohydrate reserves also exist between clones (Tew, 1970_a). These differences affect the suckering potential of various clones as well as the ability to recover from defoliation by disease or herbicide treatment.

Large variations also exist in the chemical composition and therefore in the desirability of clones as a forage source (Tew, 1970_b). The extent of root connections between trees within a clone also varies greatly (Tew, et al. 1969).

Barnes (1966) indicated various clones were differentially susceptible to biological agents such as insects, fungi, and frost. Mielke (1957) found some clones in the intermountain area were highly susceptible to the fungus *Marssonina populi* (Lib.) Mag. while others were practically immune or intermediate in susceptibility (see figure 3). The seriousness of this leaf blight depends to a great extent on the weather. If spring and summer seasons have abundant rain, more blight occurs than during dry summers.

FIGURE 3

Krebill (1972) studied aspen mortality, its causes and vegetative consequences on the Gros Ventre elk winter range. Overstory mortality was considered high because of canker fungi, stem-boring insects and physiological stress associated with bark removal by big game. Browsing and pests severely limited replacement of dying trees by sprouting.

Zahner and Crawford (1965) presented evidence to show genetic variability within aspen can be as important as other factors such as soil and topography in evaluating site quality. Clones which were genetically superior were more productive than inferior clonal material growing on the same site. Jones (1966) found different clones could give considerably different site indexes, and that clones would have to be sampled individually to make accurate estimates. Because of these differences, Warner and Harper (1972) developed a method for predicting site quality using understory species. They found sites having the best site quality for aspen also produce the greatest amount of understory forage.

Garrett and Zahner (1964) found clonal variation in vegetative reproduction often obscures the effect of various clearcutting treatments. They tested four cutting treatments, involving degree of cutting, using six different clones. The wide variation between clones in their ability to produce suckers was obvious. A range from 4,000 to 28,000 stems per acre was observed on comparable treatments 2 years after cutting, thus obscuring the effects of the cutting treatments.

Strain (1964) found variations between clones in sucker production on root sections placed under greenhouse conditions. There was an average of 2.4 suckers produced per root section on material taken from a normal clone, but an average of 3.8 suckers were produced from root sections taken from a dwarf clone. No branching was observed on the new sprouts from the normal clone, but a considerable amount was noted on dwarf sprouts. Height growth was significantly greater on the normal clone. To further test clonal variation, root material was collected from six clones at various elevations and planted in gardens at 8,100 feet and 9,750 feet elevation. Roots collected at low elevations did not produce suckers at 9,750 feet. All clones produced suckers when planted at 8,100 feet although considerable variation was noted. Growth rates were also different for each clone.

Light Intensity

Light intensity may be the critical factor controlling the growth of young sprouts. Veen (1951) found plants placed under short day conditions stopped growing and produced resting buds after a few weeks. Plants given long days kept growing well and were still developing new leaves after 8 months, with plants kept under continuous light doing especially well.

Baker (1925) found the continuous sprouting under aspen had little success until the stand was opened by cutting or by death of the older trees. He found limited success for suckers growing under light as bright as half the normal full sunlight. However, uneven-aged stands do occur where the parent stand has been altered by disease or other factors (see figure 4).

FIGURE 4

Stoeckler and Macon (1956) found aspen regeneration fairly easy to obtain, but certain conditions must be met if a full stand is desired. By cutting stands to obtain various intensities of shade, they were able to show an increase in sprouting with increased light. Annual height growth of the sprouts was also greater as light increased.

Steneker (1965) studied the effect of competition between trees in relation to periodic diameter increases. Data indicated that 3-inch trees had an increase in growth by removing adjacent trees up to 25 feet away, the 4-inch trees from cutting up to 15 feet away, and 5-inch trees from cutting up to 10 feet away. This study indicates smaller trees are more sensitive to competition than are larger trees, the reason being that small trees have large competitors and large trees have small competitors.

Many observers have been puzzled by the usual lack of aspen invasion into open areas where light intensity is not a problem. Baker (1925) stated this may be caused by the destruction of the scattered sprouts by grazing animals. Lynch (1955) indicates the stability of the adjacent grasslands results from the usual inability of aspen to become established from seed. The inability to invade by root sprouts is related to competition for soil moisture and the suppression by livestock grazing.

Buell and Buell (1959) were curious as to what type of root system the small unsuccessful sprouts appearing in the grasslands might have. They excavated the root system of a small stem occurring 20 meters from the edge of the nearest aspen. A uniform diameter root was followed for

31.7 meters into the aspen thicket. The root remained between 3 and 15 cm below the soil surface most of the way, although it did go to 90 cm at one point. They concluded that the absence of a substantial root system of its own, resulting in the dependency on the parent tree for food, may account for the inability to invade the prairie.

Treatment Effects

Season of Cutting

Brown (1935) states that sucker buds can be found on the roots at any time during the year. The cambial activity commences during the early part of May, and the first indication of cessation occurs in the latter part of August. This work agrees well with Baker (1918_a) who found a continuous sucker production under aspen although the sprouts are usually weak and seldom reach great heights before they die of suppression. Seasonal variation in sucker production is likely caused by factors other than the presence or absence of sucker buds.

Baker (1918_a) tested season of cutting as a factor affecting reproduction by clear cutting during the spring, summer, and fall on 70, 90, and 110 year-old stands in central Utah. Maximum sprouting (85,520 sprouts per acre) was obtained on a spring cut plot. Summer and fall cut plots produced approximately half as many sprouts by the end of the first growing season. However, after 4 years all stands had approximately equal numbers with 20,000 to 30,000 sprouts per acre. Stoeckler and Macon (1956) found the number of sprouts produced in late summer cutting was only 74 to 78 percent as great as when the cutting was done in the dormant season or in the spring. Zehngraff (1949) found revegetation in Minnesota was unsatisfactory on areas logged in the summer, even on clear cut areas. This was attributed to the depletion of food reserves with weak suckers being produced which were easily winter killed. Also, many brush species became established before the aspen causing serious competition the following year.

Effects of Cutting

After timber removal during any season, many changes in the understory will occur. Marston and Julander (1961) found a rapid increase in perennial grasses and forbs immediately after aspen removal. After a few years, however, perennials decreased and annual plants and bare ground increased. Gophers were responsible for a large portion of the decline of perennial grasses and desirable forbs. Eleven years after treatment, gopher mounds were twice as numerous on the plots where aspen had been removed as on untreated plots. Similar long-time changes will occur on any site where a treatment is applied.

Grazing

Sampson (1919) did the first work on the effect of cattle and sheep grazing on aspen sprouts. He found the injury and mortality rate was directly related to the closeness of grazing. On clear-cut areas, sheep cause heavy losses in young sprouts. The stand may be destroyed by three successive years of heavy grazing. Cattle do not kill as large a proportion as sheep.

Sprout height controls the amount of damage being done by cattle and sheep grazing. By the time sprouts reach 45 inches, damage by sheep is no longer a problem. The average height increment is about 15 inches per year; therefore, after 3 years, sprouts are not damaged extensively by sheep. For cattle, the period would be 4 or 5 years.

Not all grazing is necessarily harmful to the young sprouts. Removal of the terminal shoot once or twice will not kill the plant because lateral shoots can develop. Maini (1966) found some lateral buds have a growth potential greater than the apical stem. Decapitation of suckers did not significantly reduce the overall height increment, and in some cases the decapitated suckers had greater growth than intact stems. Other complications may enter, however. Packard (1942) found that even though light browsing by deer did not directly affect growth, fungus infection was more likely to appear and damage the stems. Other factors such as frost damage and attack by small mammals may be equally important in the destruction of sprouts.

Root Connections

One factor which might give aspen a distinct advantage in competing with other species in the community is that young sprouts are connected to a common root system with the parent trees (see figure 5).

FIGURE 5

Barnes (1966) excavated the root systems of approximately 106 trees. In two instances, 15 or more trees were connected on a common root system. No predictable or systematic arrangement of the connections was found, however. DeByle (1964) developed a tracer method for following root connections without excavation. Eosine bluish dye and sodium arsenite were the best tracers tested. The tracers were injected into a total of 119 stems in four stands of varying ages. From zero to six receptors were present in each stand with the exception of one having 10 receptors. Day (1944) traced the root system of an 18 year-old tree having a main lateral root 47 feet in length. This root had eight suckers present. At each sucker, there was a thickening of the root on the side away from the parent tree indicating translocation of food material from the leaves was going towards the growing tip and not towards the parent tree.

Strothmann and Zasada (1957) state that although suckers are initially supported by the parent tree, a root system of their own is rapidly developed. Work by Gifford (1966) failed to support this statement, however. He excavated 29 trees and found 9 of these which had no vertical secondary roots. There were 12 trees which had no lateral root development of their own. A total of seven trees had no root development at all, other than the parent root.

Although most aspen in the western states developed from root suckering, some cases of seedling establishment have been reported. Ellison (1943) located an aspen seedling at 11,000 feet elevation in southeastern Utah. The seedling was less than a foot tall even though it was 5 years old. No trees were located within a mile of this seedling. Larson (1944) also reported the establishment of many seedlings along the receded shoreline of Strawberry Reservoir in Utah. Several plants were dug up and all had a long tap root with no attachment to a parent tree.

Fire and Soil Temperature

Fire is another factor which affects the sprouting and stability of aspen stands. Work by Fetherolf (1917) and Baker (1918_b) shows that repeated fires in the past have eliminated the conifers and favored the aspen which can reproduce by sprouts. The trend has been reversed in recent years because of changed grazing practices and fire protection. Gymnosperms are now able to establish in these stands and might eventually replace aspen because of its intolerance to shade.

Shirley (1931, 1932) found even a light burn will increase the number of suckers. This holds true on clear-cut, partially cut, and uncut areas. The average height of suckers is also increased. Apparently the blackened surface warms earlier in the season and stimulates the chemical activity within the roots making stored food more readily available for the sprouts. If an area is repeatedly burned, however, this trend may not hold. Stoeckler (1948) found a reduction in the site index on areas which had undergone repeated burnings. The loss of litter from these sites may be partially responsible for this reduction.

Horton and Hopkins (1965) tested various burning conditions in the field and laboratory and found root suckering occurred under all burning intensities. Lethal soil temperatures were attained only near the surface in very dry soil indicating control of suckering likely could not be done with fire. Moderate burning which kills the tree canopy and eliminates some litter will stimulate the most suckering while light burning is ineffective in producing a good sprout stand.

Maini and Horton (1964, 1966) tested soil temperature as a factor affecting suckering on root cuttings placed in sand. Temperatures were varied from 58 to 95 F. At the extreme temperatures, conditions were unfavorable for sucker production. The best emergence was obtained at 87 F requiring only 8 days for sprouts to appear, but the greatest growth was at 74 F. Approximately 14 days were required for emergence at 74 and 95 F.

Soil Properties

Soil factors may control many of the characteristics of aspen and understory on any given site. Heinselman and Zasada (1955) state that abundant calcium in the soil contributes to the longevity and soundness of aspen. Voight, Heinselman, and Zasada (1957) found four times greater growth on soils with high levels of calcium, magnesium, and nitrogen than on soils with poor base status and nitrogen content.

Stoeckler (1960) indicated pH, nitrogen status, and calcium content were related to site index although no correlation could be found between available potassium and site index. An extreme contrast was noted in the calcium and magnesium content of the soil on good sites compared to poor quality sites.

Stoeckler (1948) found texture, which is related to the exchange capacity, was the most important factor in determining site quality for aspen. The amount of silt-plus-clay was especially important. Soils having 50 to 55 percent silt-plus-clay were the most productive. If higher percentages were present, aeration became a problem. If smaller quantities were found, the soil lacked the fertility to produce optimum growth.

Strothmann (1960) used a combination of soil and topographic ratings to evaluate a site. The percent silt-plus-clay and stoniness in the upper 36 inches, subsoil pH, and depth to the water table were the soil factors considered. Aspect, steepness of slope, and postion on the slope were the topographic factors considered.

Maini and Horton (1964) evaluated soil moisture content in relation to sucker production from root cuttings. Sucker production was decreased as soil moisture increased. No suckers appeared under the saturated and flooded soil conditions showing aeration becomes a limiting factor. Under field conditions they found 77 percent of the suckers coming from roots less than 2 inches below the surface where satisfactory aeration was present. It was also noted that 93 percent of the suckers were produced on roots less than an inch in diameter.

Soil depth and type of parent material are also important factors in aspen production. Crowther and Harper (1965) found aspen growing in strips along the hillside in Utah. Aspen was found on areas with deep soils developed from limestone parent material. The shallow soil in the alternating strips was developed from quartzite and was occupied by oak and other mountain brush species.

Plant Chemistry

Auxins

With wide variation in the various chemical elements, differences in other substances such as auxins might be expected. These substances may have a controlling influence on reproduction and rooting ability of aspen. Farmer (1963) treated cuttings taken from root suckers with aqueous solutions of indolebutryic acid (20-100ppm) and found this stimulated rooting. Snow (1938) rooted dormant cuttings from aspen by treating the stems for 27 hours with a solution containing 70 milligrams of indolebutryic acid per liter. Best rooting was obtained by taking cuttings just before the buds burst in the spring.

Vegetative reproduction may be auxin controlled, as large numbers of root sprouts appear if mature trees are cut, thereby removing the apical dominance. Farmer (1962) proposed that root sucker formation was controlled by the presence of an intact, growing apical bud. The degree of apical dominance varies within the species and this has an influence on the plant growth habit. He states that suckers appear on root systems after the stems are cut or disturbed, but not while the tree is undamaged and growing vigorously. Applications of indoleacetic acid in lanolin to stems which had the apical portion removed inhibited suckering on the root system. This shows the importance of auxins in the apical portion of the stem in controlling vegetative reproduction. Growth regulating substances are likely translocated from the stem into the roots and thereby prevent suckering in the intact root system. If this is true, factors controlling the production of auxin within the apical portion of the plant may have a controlling influence on suckering. For example, zinc may control the production of tryptophan which in turn is converted to auxin.

Carbohydrate Reserves

In addition to the zinc status of plants, which may affect auxin production and enzyme activity, carbohydrate reserves likely have a controlling influence on root sucker production. Clonal variation, as well as many environmental factors are known to influence the quantities of root reserves present in a plant. Tew (1970) found aspen defoliation caused by leaf diseases followed by a regrowth of stress leaves depleted root reserves.

Mooney and Billings (1965) found carbohydrate reserves were higher in several alpine plants when growing near the lower altitudinal limits of the species. If plants were moved from a higher to a lower and warmer elevation, stored carbohydrates were used up more rapidly than at the elevation of origin. The higher carbohydrate concentrations in populations near the lower altitudinal limits therefore appears to be an ecotypic adaptation.

McConnell and Garrison (1966) found cycling of carbohydrates in bitterbrush where accumulations declined during the early growing season with an extended period of low levels during the rapid twig growth and seed formation stages. Reserves then began to build up until leaf fall, restoring carbohydrate accumulations to a point a little above their prevernal level. Because similar cycling occurs in aspen, root suckering is surely affected during some seasons of the year.

DISCUSSION

Buds are present on roots throughout most of the summer months. However, abundant reproduction does not occur unless roots are injured or the parent stand is modified by disease, cutting, or some other factor which reduces apical dominance and also opens the stand. In areas where grazing patterns have not changed drastically over the past few years, it appears that changes in apical dominance and openness of the stands due to disease and mortality of parent stands are primarily responsible for aspen invasion of meadows (see figure 6).

FIGURE 6

This does not mean that grazing has not been important in controlling aspen invading the meadows years ago, but that since better management practices have been applied in the past few years and overgrazing has been reduced, the young sprouts are now able to establish more successfully.

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USE OF RUMINANTS AS A MANAGEMENT TOOL

Paper presented at the International
Congress on Dryland Farming, 1980
Adelaide, Australia
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Use of domesticated ruminant animals on range and cultivated lands traditionally has stressed their role as producers of meat, wool, hair, leather, and pharmaceuticals. Additionally, they often are used as a source of draft power and a measure of wealth. More recent attention has been given to their value as tools for managing wild and cultivated lands.

Under proper management, they may be used on wildlands to alter plant species composition to favor other classes of domestic animals or wildlife. Hubbard and Sanderson (1961) and Jensen et al. (1972) found on properly stocked ranges, grazing herbaceous species by livestock increased leader growth on bitterbrush (Purshia tridentata), an important browse species for wintering mule deer. Hedrick et al. (1971) noted that light browsing by cattle in the spring and early summer maintained browse in an available form for deer. Biswell et al. (1952) and Hedrick et al. (1968) found that sheep and cattle grazing suppress rapid growth of shrub sprouts thereby prolonging availability of deer browse in the first few years after fire or timber harvest.

Anderson and Scherzinger (1975) used a specially designed livestock grazing system to improve winter elk feed. Cattle were used to "top-off" bunchgrasses before the mid-growing season. This improved the availability and quality of feed for wintering elk herds by eliminating the coarse, dead plant material which had been building up in the grass crowns with elk use only. Elk numbers had more than tripled (from 320 to 1190 head) on the area 14 years after establishment of the grazing system.

Sheep grazing in late fall helped control reinvasion of big sagebrush (Artemesia tridentata) on seeded cattle range if the practice was initiated before sagebrush became too dense (Frischknecht and Harris 1973). This method of biological control greatly reduced the need for costly chemical or mechanical sagebrush control treatments.

Sharrow and Mosher (1980) found that sheep, which are essentially immune to the toxic properties in tansy ragwort (Senecio jacobaea) can be used as effective biological control agents for reducing this introduced weedy species. Cattle, goats and horses, as well as many monogastric animals are highly susceptible to the toxic properties in tansy ragwort. Intensive grazing by sheep can reduce its ability to flower and produce seed, thereby maintaining it at acceptable populations.

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In central Oregon, Stuth and Winward (1977) found that meadows ungrazed by cattle were dominated by grass and grasslike species with only ten broadleaf forbs present. Grazed meadows, on the other hand, had from 15 to 20 forbs present. Deer which use the meadows in the spring and summer maintain a forb dominated diet in these meadows. Therefore, they concluded that moderate use of these meadows by cattle may be complementary to deer by providing a greater diversity of desirable forb species. They also stated that the additional forbs in the grazed meadows created contrasts in the landscape color and pattern that conveyed a different aesthetic impression than uniform grass-sedge vegetation.

In a forest-grazing study, Douglas fir (Pseudotsuga menziesii) seedlings grew faster in plots subjected to carefully controlled, short-term spring sheep grazing than in ungrazed plots (Hedrick and Keniston 1966). Ten years after grazing was initiated, Douglas fir tree heights averaged 63.5 cm (27 percent greater) on grazed than ungrazed plots. Additional soil moisture at 13 and 30 cm depth correlated well with removal of herbage by sheep and was believed to be the primary factor related to increased tree growth.

On areas where prescribed fire requires a special prescription for effective and safe burning, livestock can be used to alter the amount and type of fuel present (CAST 1974). Rate of spread of the fire and heat intensity are influenced by the fuel load which in turn, often can be regulated by grazing animals.

On cultivated lands, ruminants can serve an economic role in utilizing crop residues which potentially become pollutants or wastes and require considerable expenses for disposal (Hodgson 1976). Livestock enterprises allow use of forage legumes in cropping systems which reduce or, in some cases, largely eliminate the need for nitrogen fertilizers. Well adapted perennial forage legumes can contribute 18-36 kg/ha of nitrogen to the soil annually for use in subsequent crop production (TAB-AID 1976).

A rotational sequence of pasture and crop has potential for reducing insect pests, nematodes, plant diseases, and certain weeds that could otherwise reduce crop yields. Inclusion of perennial forage grasses in a crop rotation system also effectively reduces soil erosion and improves soil structure and permeability (TAB-AID 1976).

Ruminant animals will continue to serve their traditional role in harvesting and converting fibrous plant material into palatable, edible food for humans. Their future role also will stress non-product values received through using them as tools for management.

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